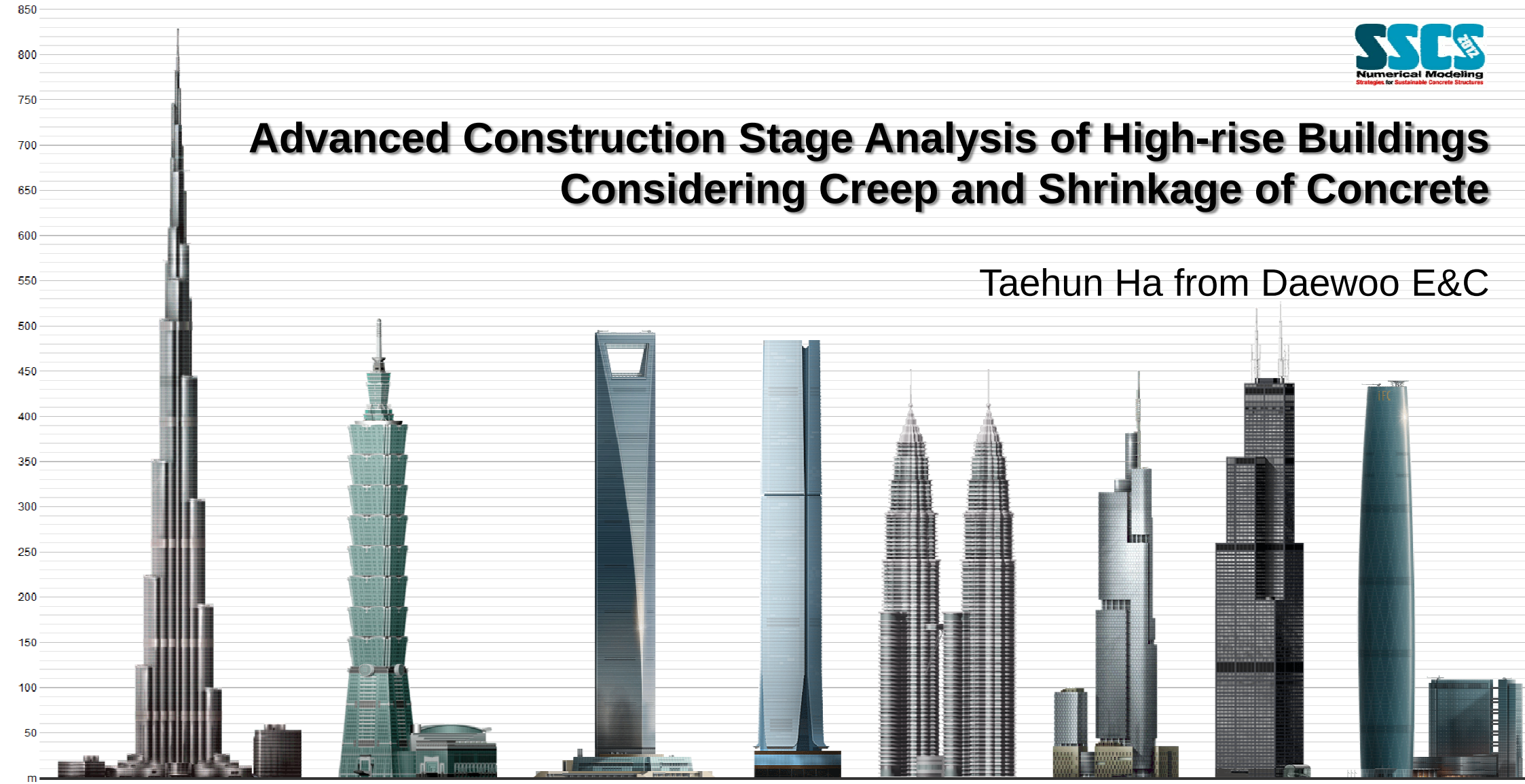
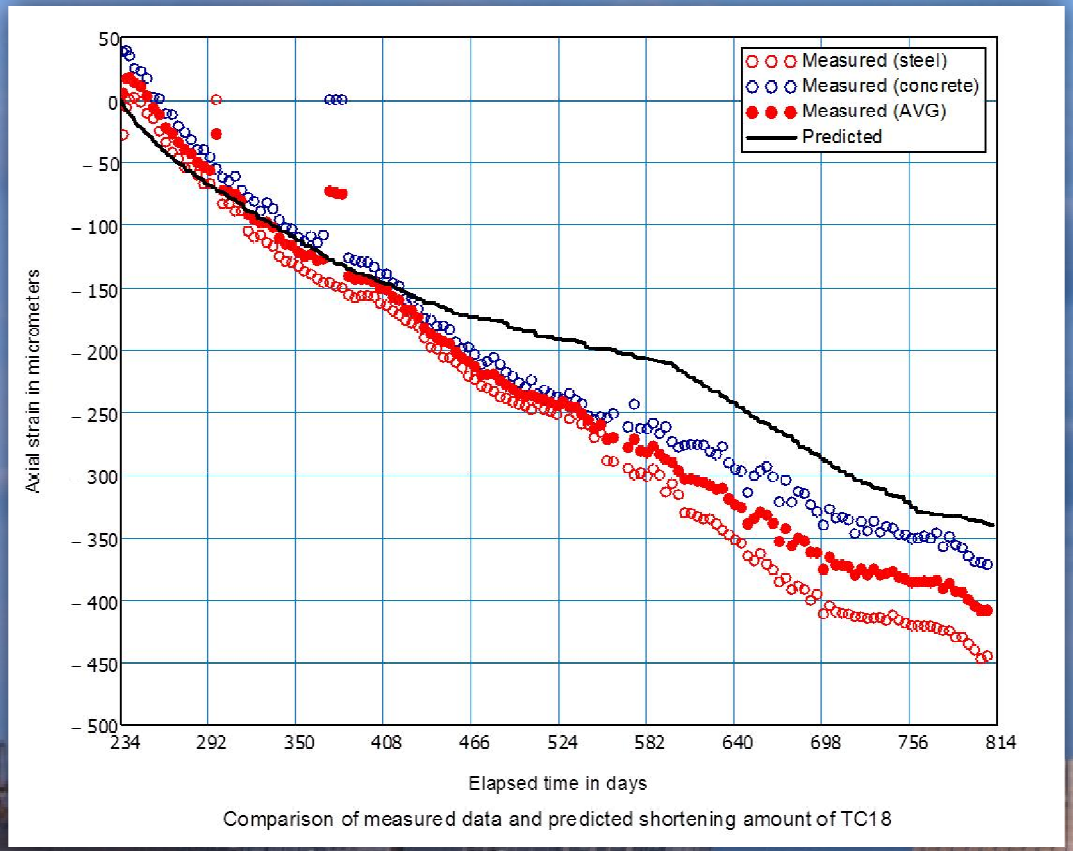
Advanced Construction Stage Analysis of High-rise Buildings Considering Creep and Shrinkage of Concrete

Taehun Ha from Daewoo E&C



NEATT in Incheon Korea



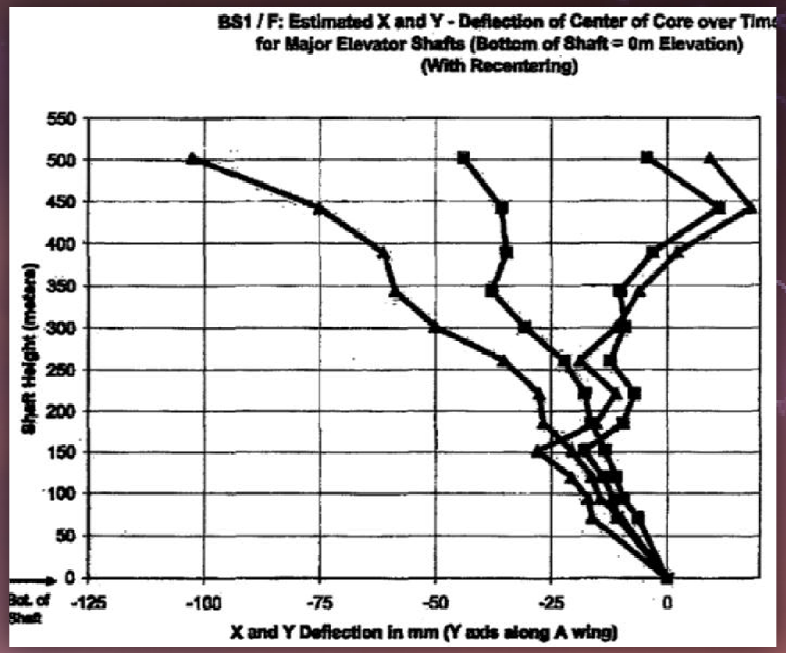
Comparison of measured data and predicted shortening amount of TC18

305m above ground, currently tallest building in South Korea.
Axial shortening was predicted more than 200mm and was verified in field monitoring.

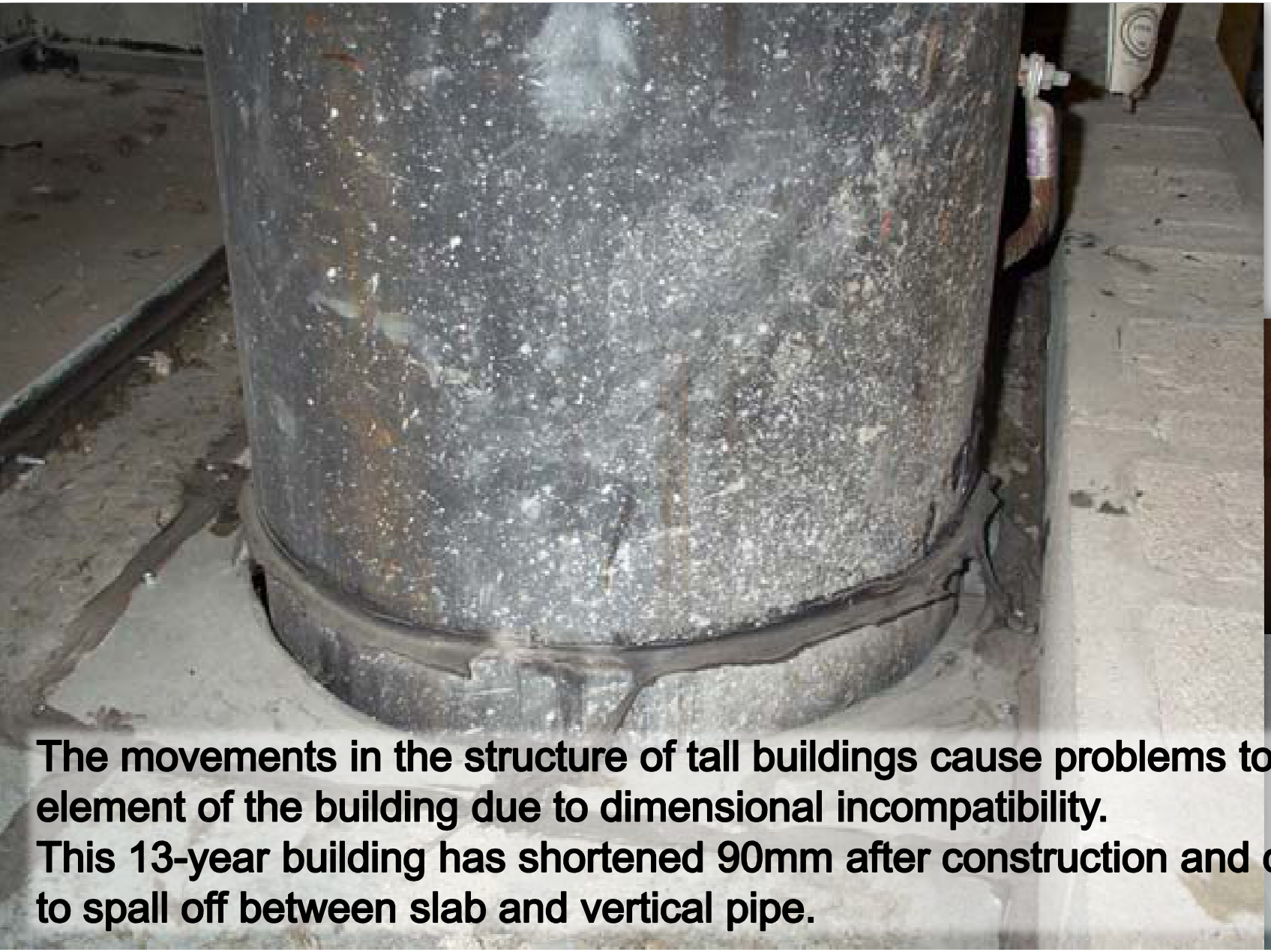
Picture courtesy of Samsung E&C

Burj Khalifa

848m above ground, currently tallest building in the world.
Lateral movement was predicted more than 100mm and was verified by GPS survey.



Problems



The movements in the structure of tall buildings cause problems to non-structural element of the building due to dimensional incompatibility.
This 13-year building has shortened 90mm after construction and causes the sealing to spall off between slab and vertical pipe.

Problems

In the same building, the bracket for elevator rail moved with the lift core that it scratched down the elevator rail by 90mm.

Problems

The confined differential shortening on both sides of this deep beam caused critical diagonal cracking after construction.

Solutions

at Design

- Member section
- Material selection

during Construction

- Adjustment or delay joint
- Design or material change
- Structure preset or compensation (last resort)

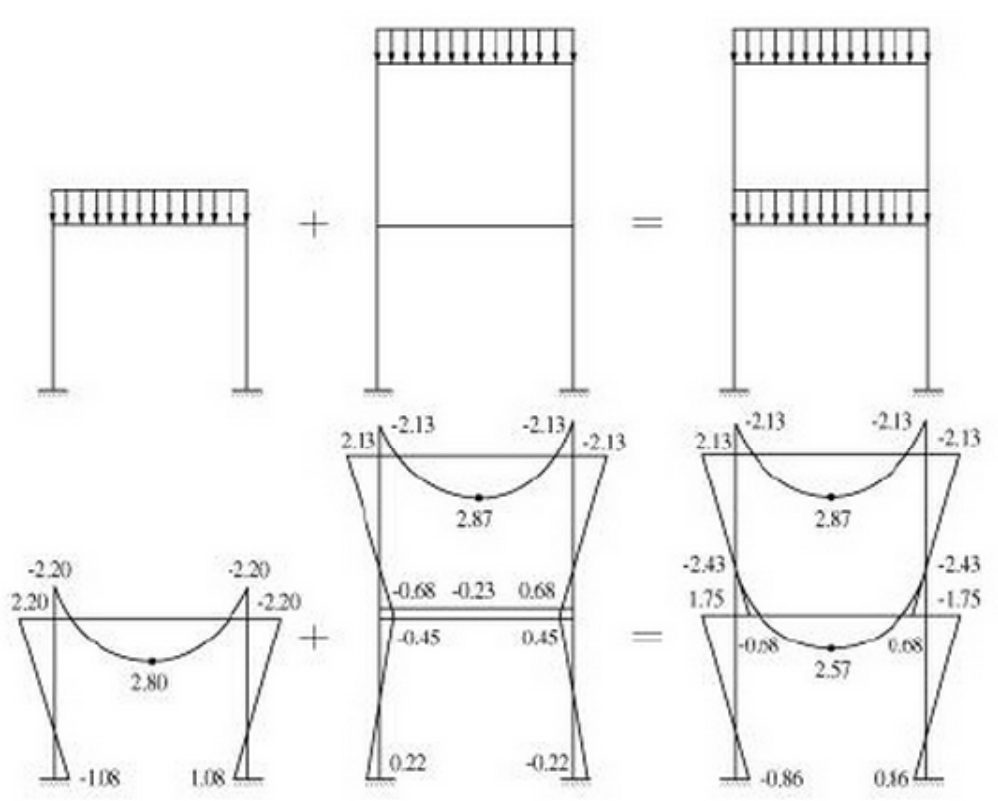
Building Movement Control

Monitoring

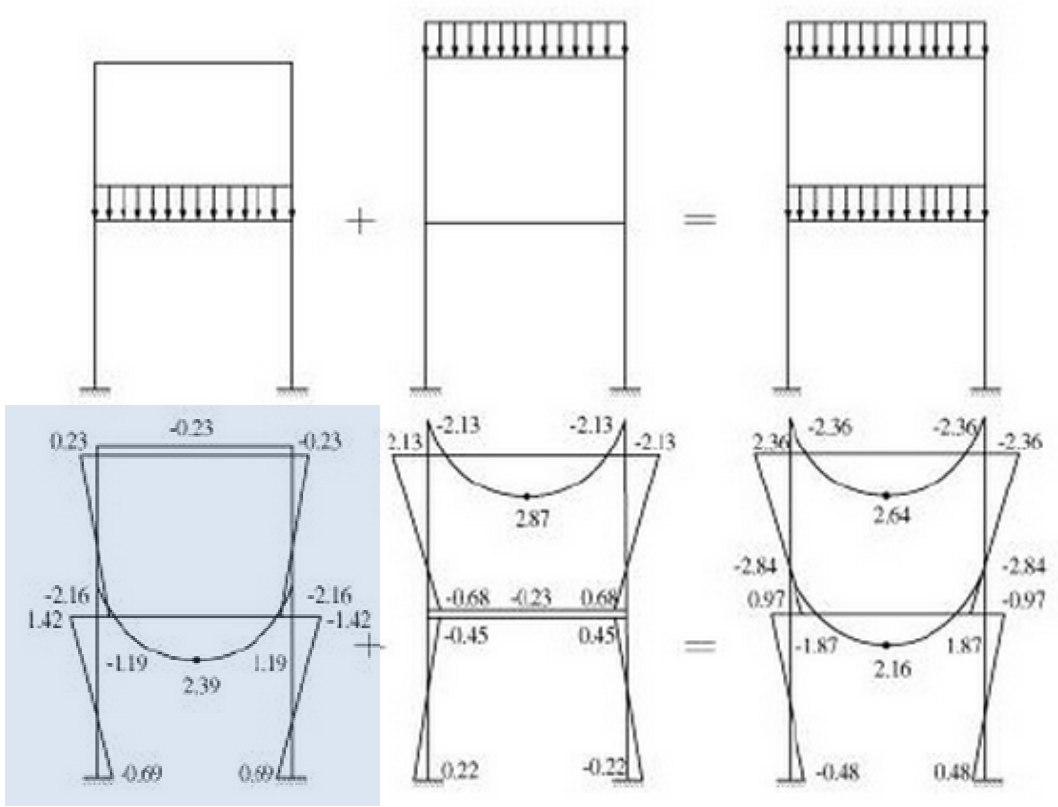
Time-dependent
Material testing

Construction stage analysis

Construction Stage Analysis



Construction Stage Analysis

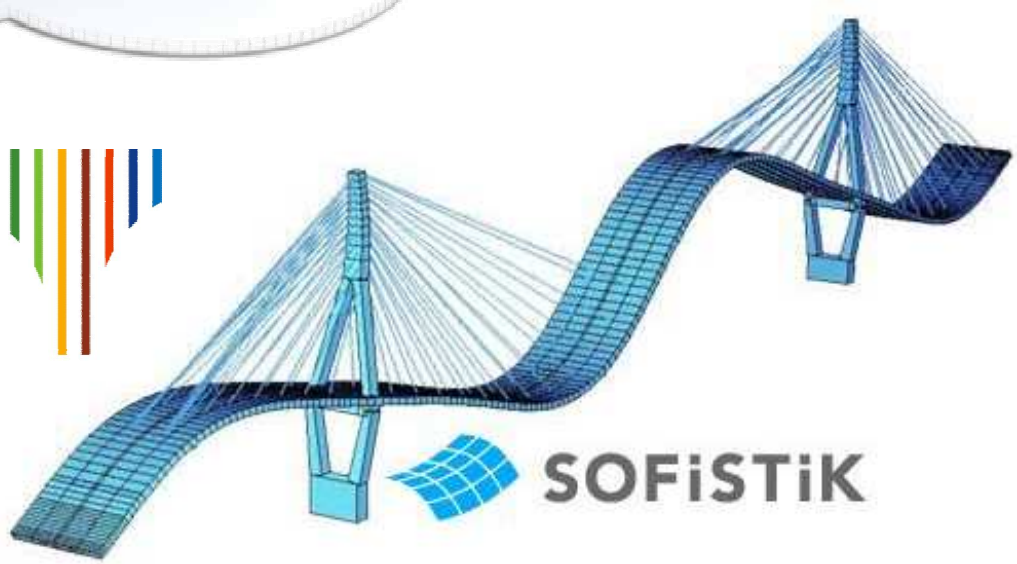


Normal Structural Analysis

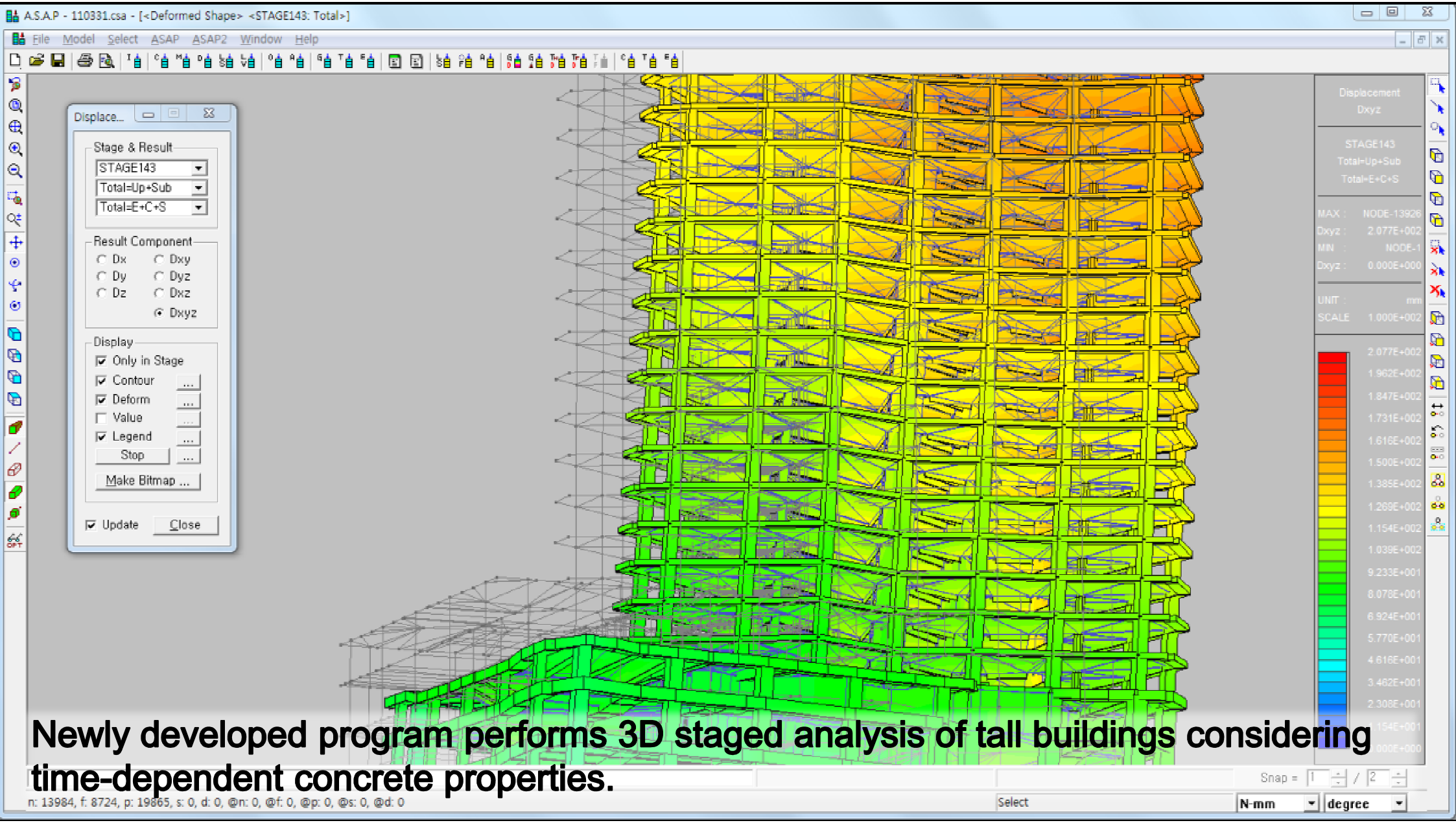
Construction stage analysis usually results in more member forces in lower levels and less member forces in higher levels.

Commercial software

Scia Engineer

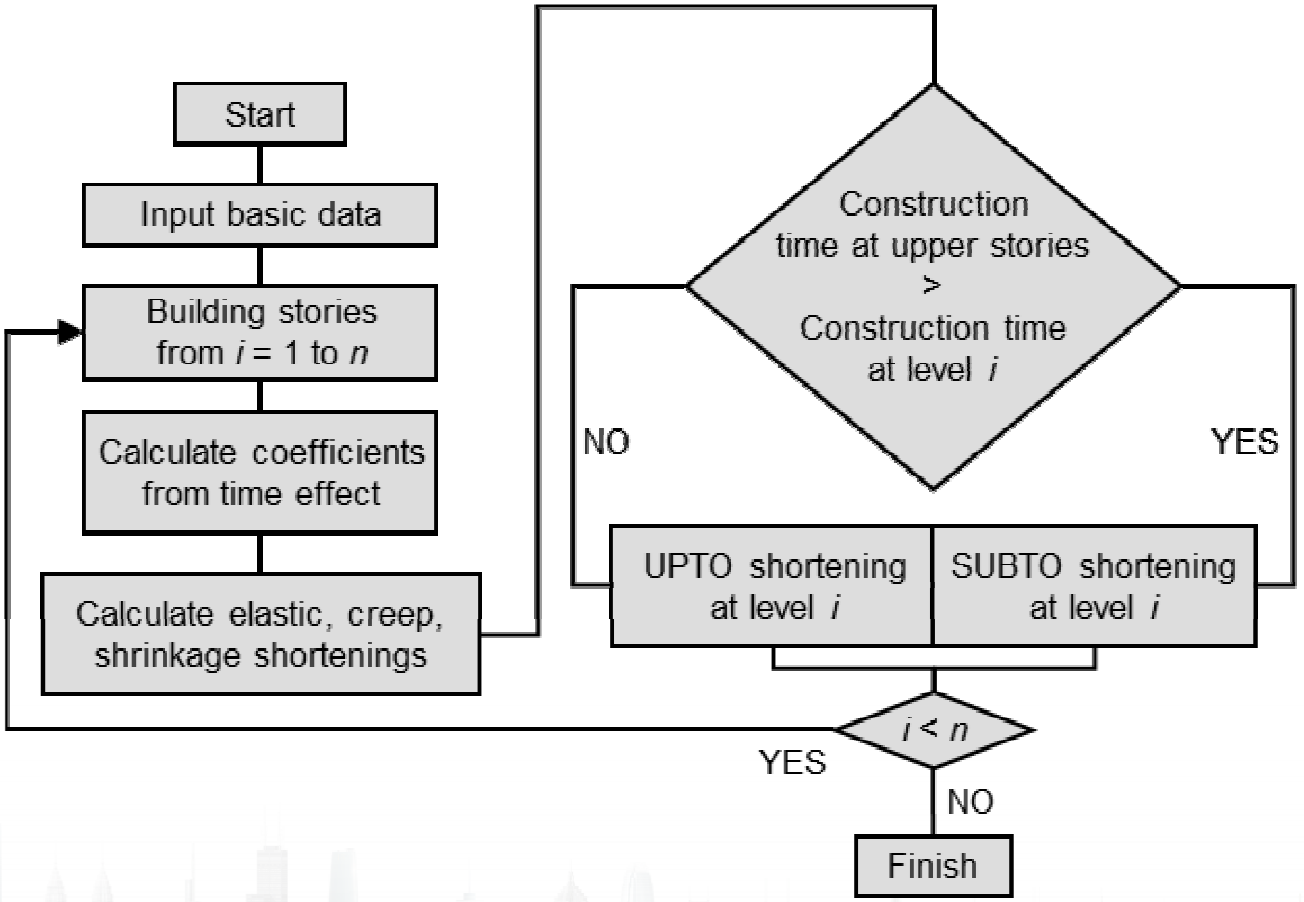


Several commercial software for structural analysis considering construction stage is on the market but they are not specially focused on tall buildings.



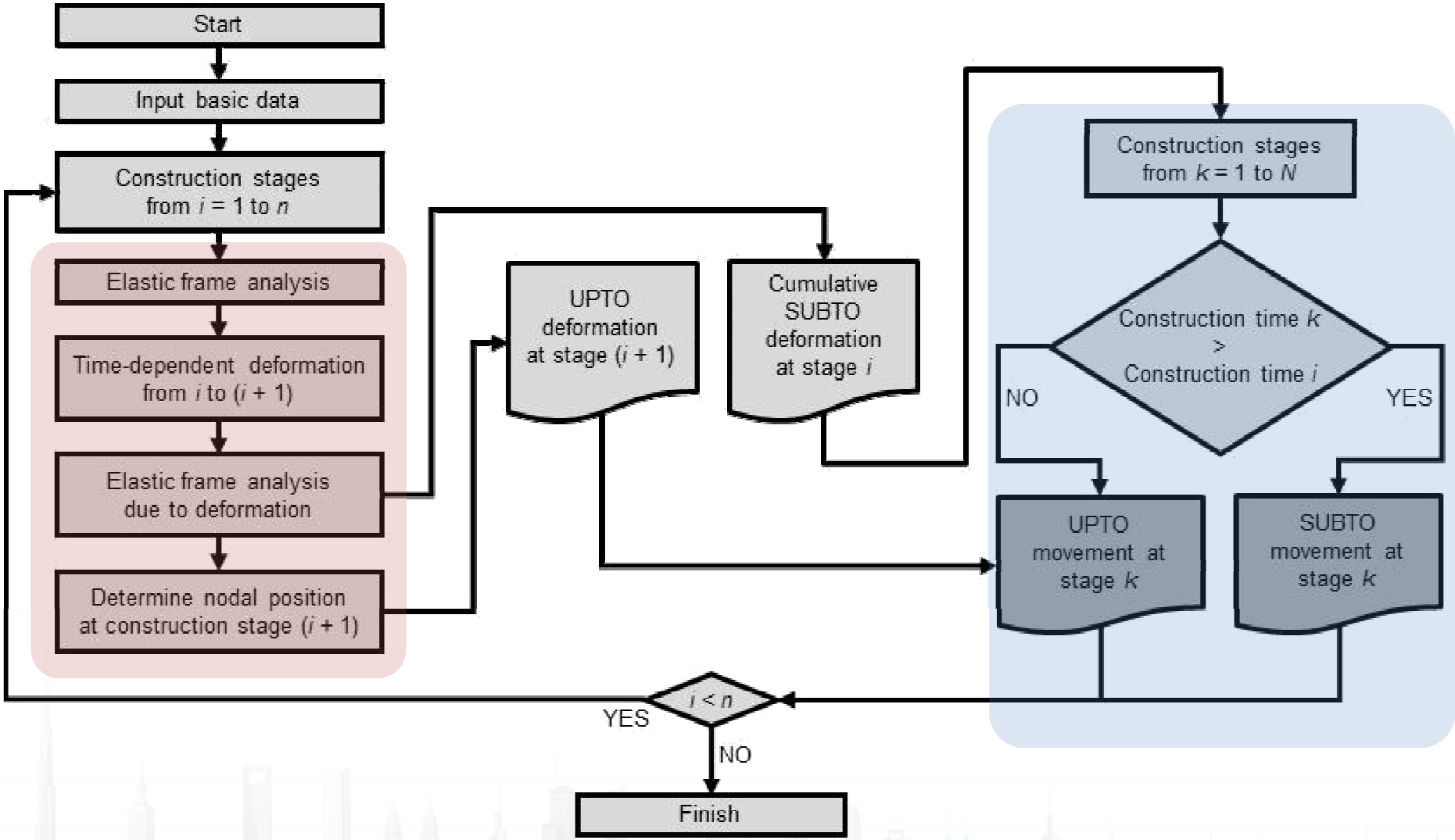
Newly developed program performs 3D staged analysis of tall buildings considering time-dependent concrete properties.

Algorithm in the past



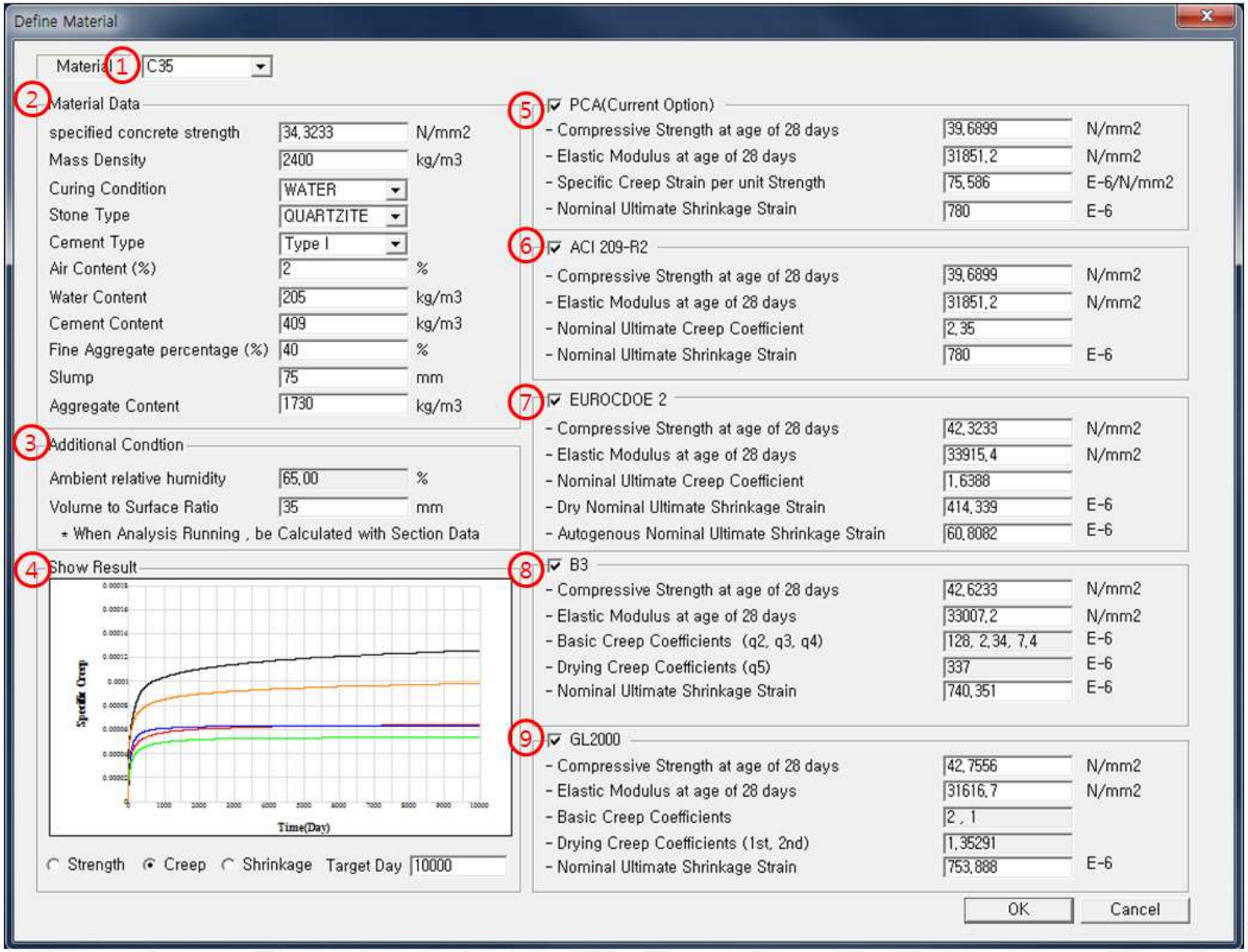
In the legacy column shortening program, each of vertical members is evaluated for its individual deformation considering the construction of each story.

Revised algorithm



Newly developed software performs 3D analysis based on time-dependent creation and extinction of each node and can divided the movement by multiple target days.

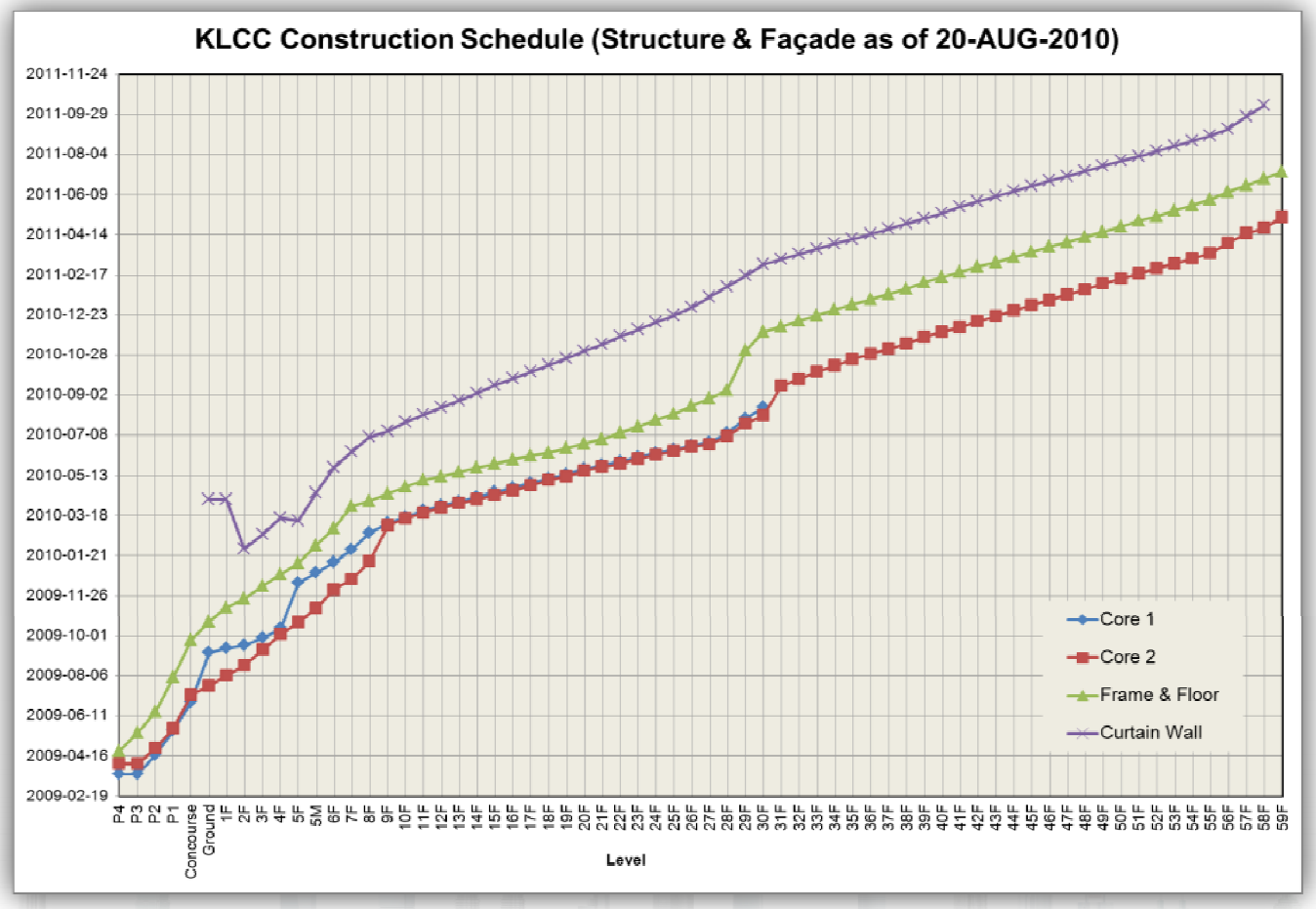
Creep & Shrinkage

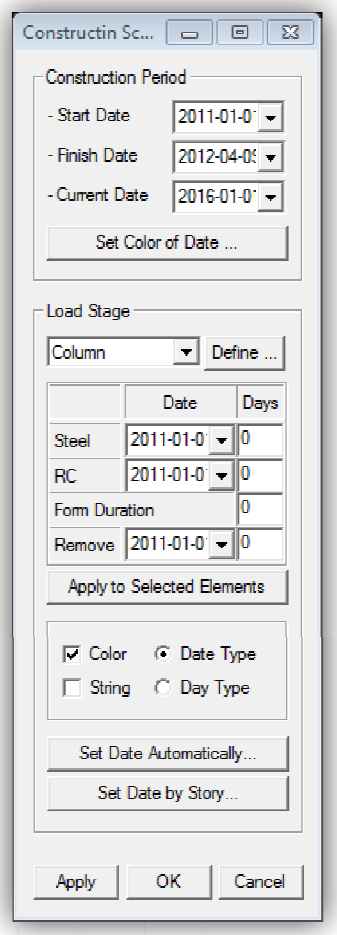


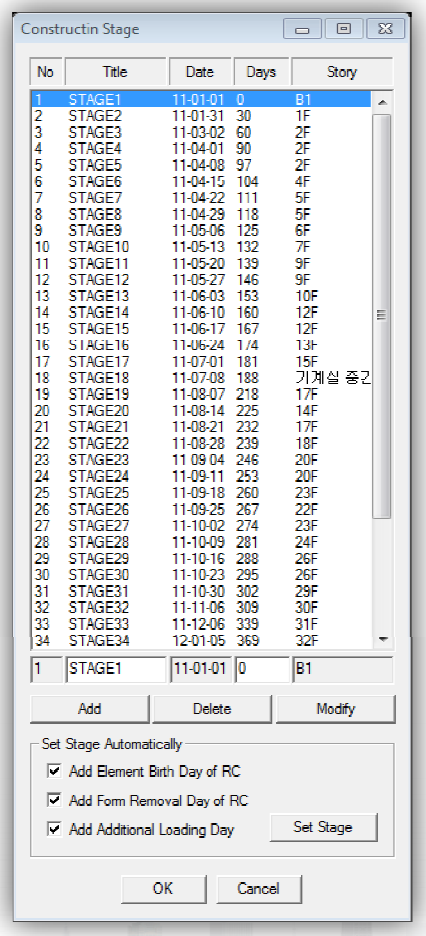
Picture from Advanced courses in creep and shrinkage held in Udine, Italy, 2011.5.23~27

Several state-of-the-art material properties can be compared for their final results.

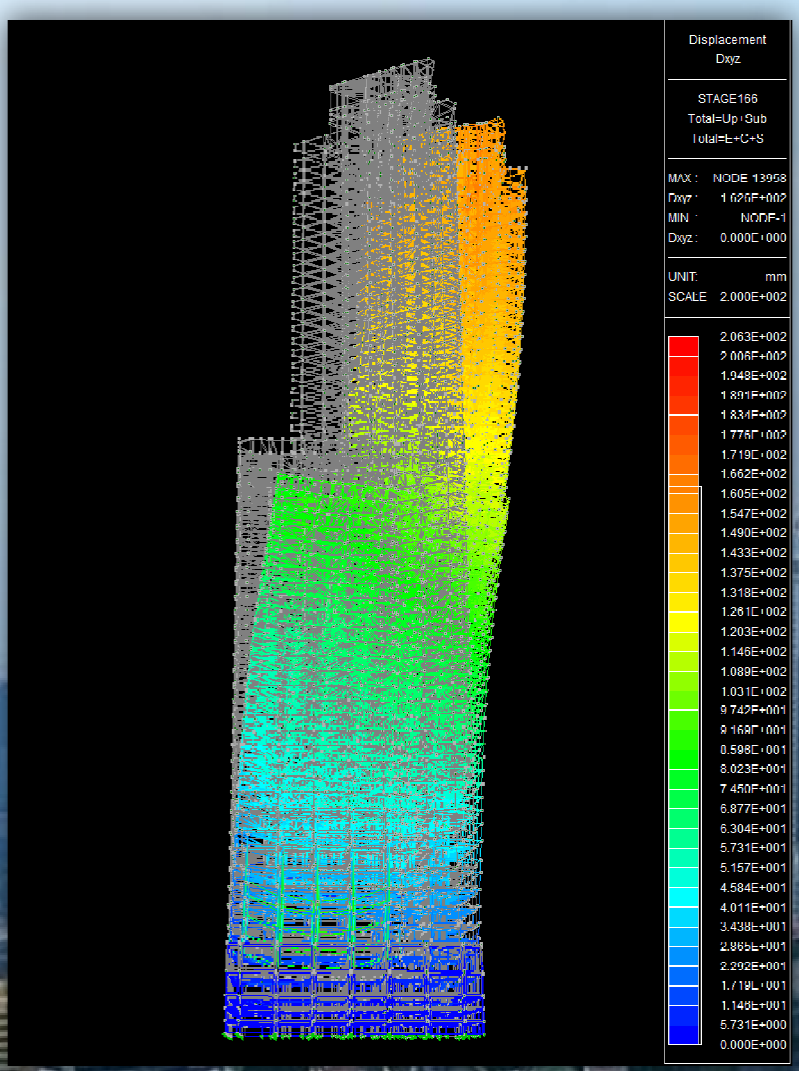
Construction Stages

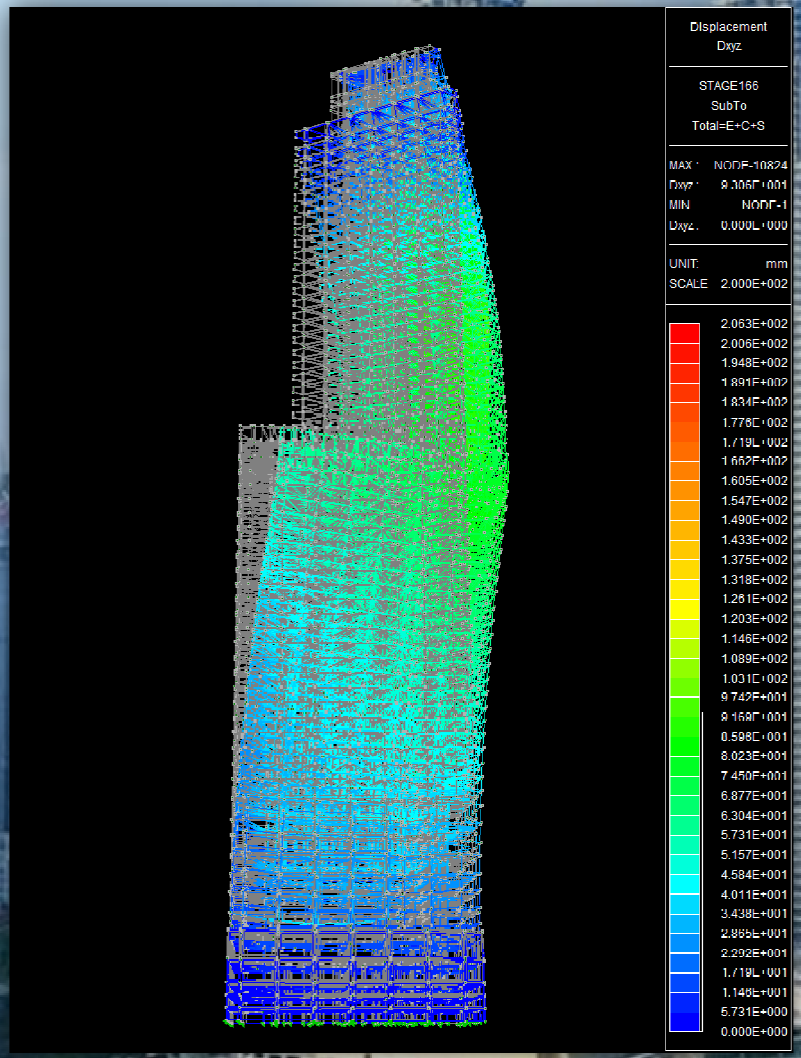






Complex construction schedules including shoring schemes can be easily imported from tabulated ASCII file and important dates are chosen as analysis stages

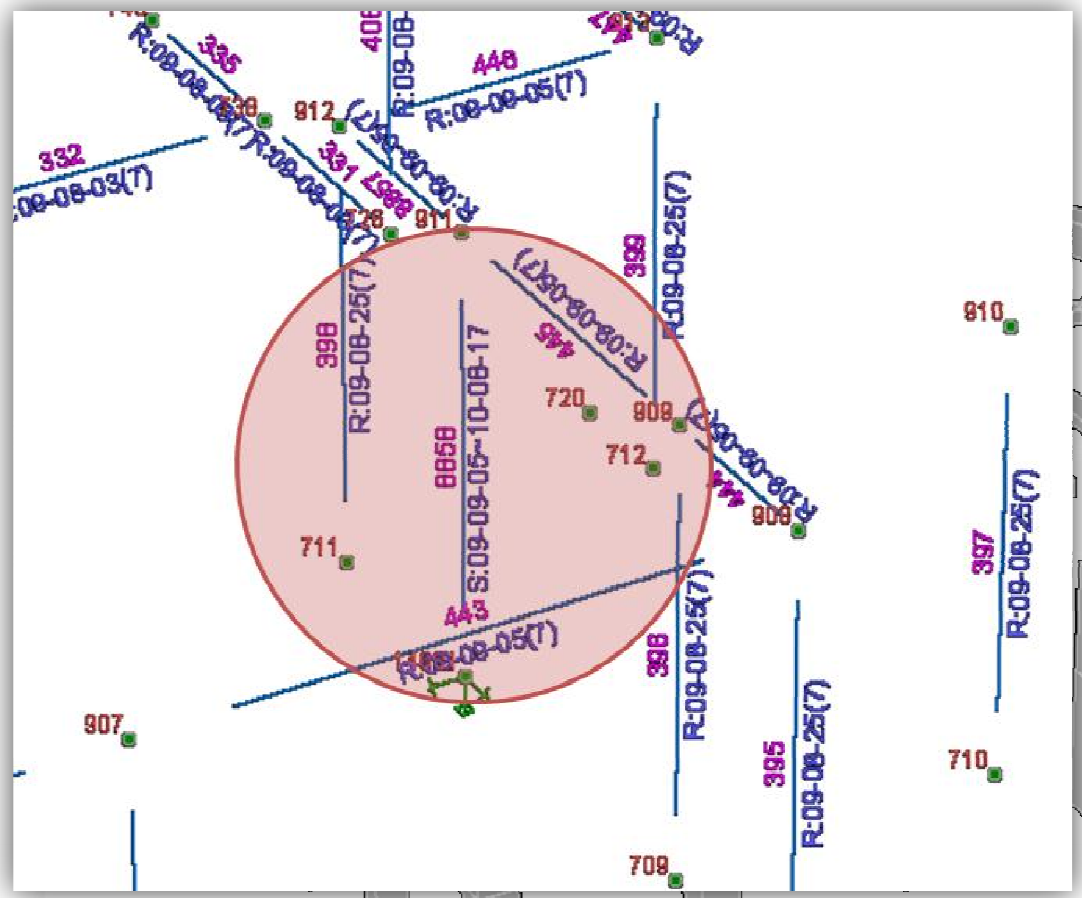


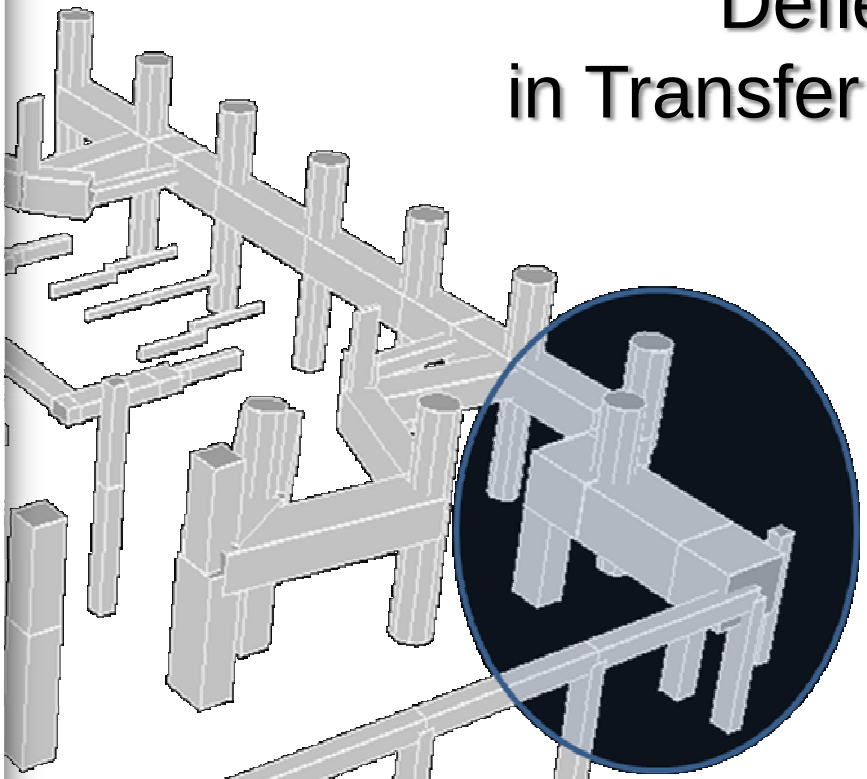


KLCC Tower Project

KLCC Tower in Kuala Lumpur is a 58-story eccentrically arranged tall building. Well-thought-out compensation was performed to prevent problems caused by movement

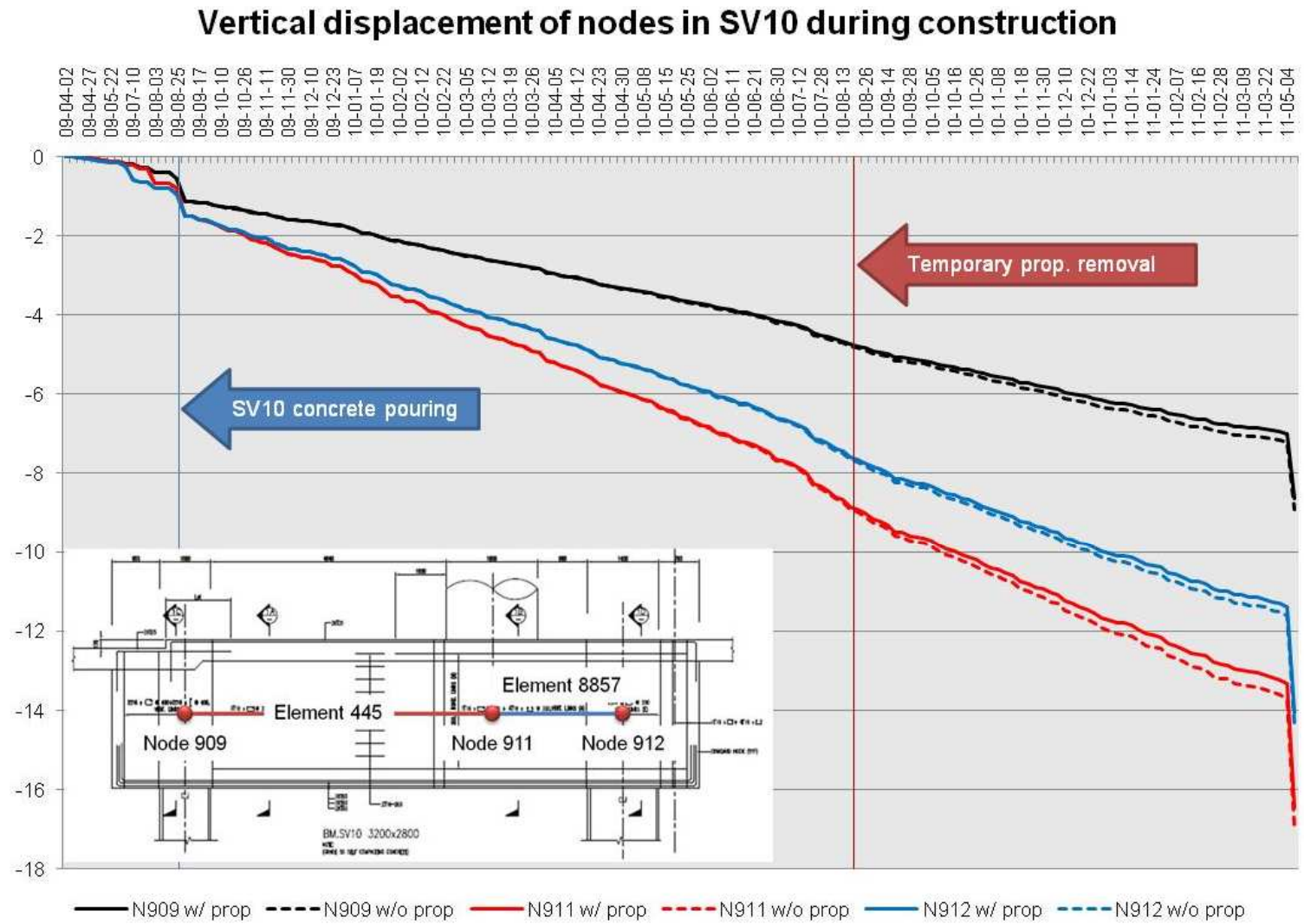
Deflections in Transfer Girder





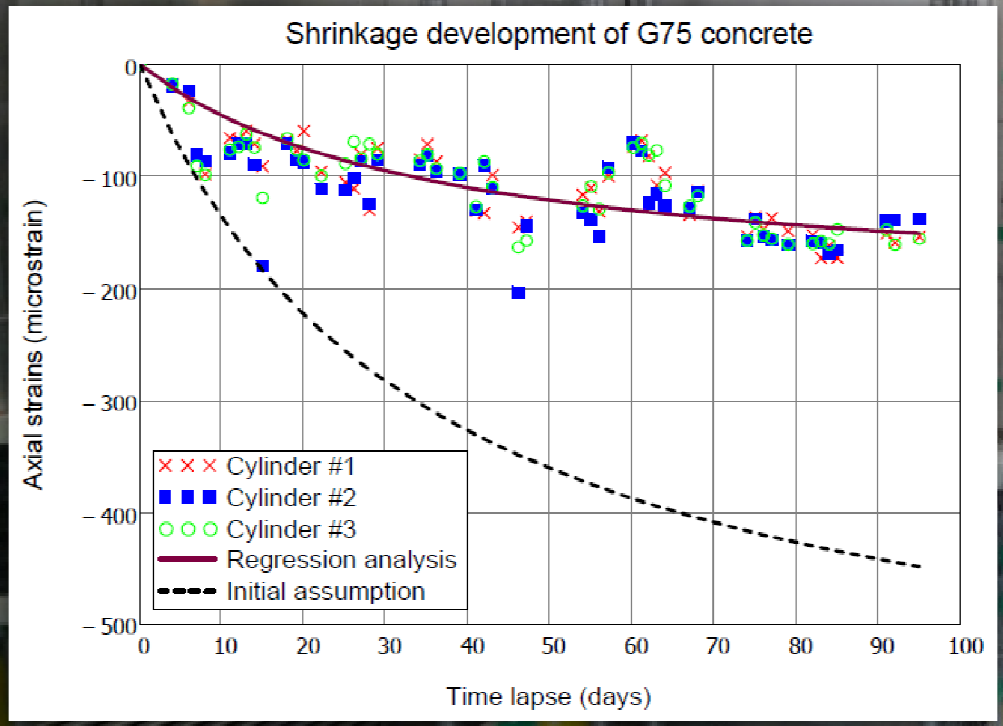
The transfer girder in the street level is considered structurally important, preventing the contractor from removing the temporary support until the completion of level 30.

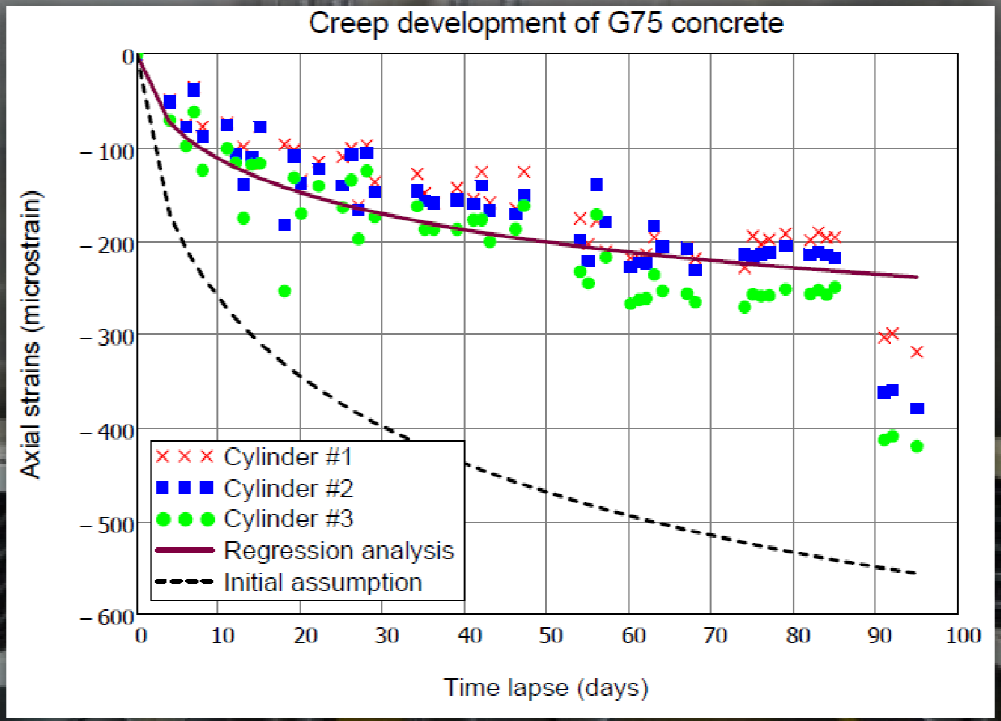
Deflections in Transfer Girder



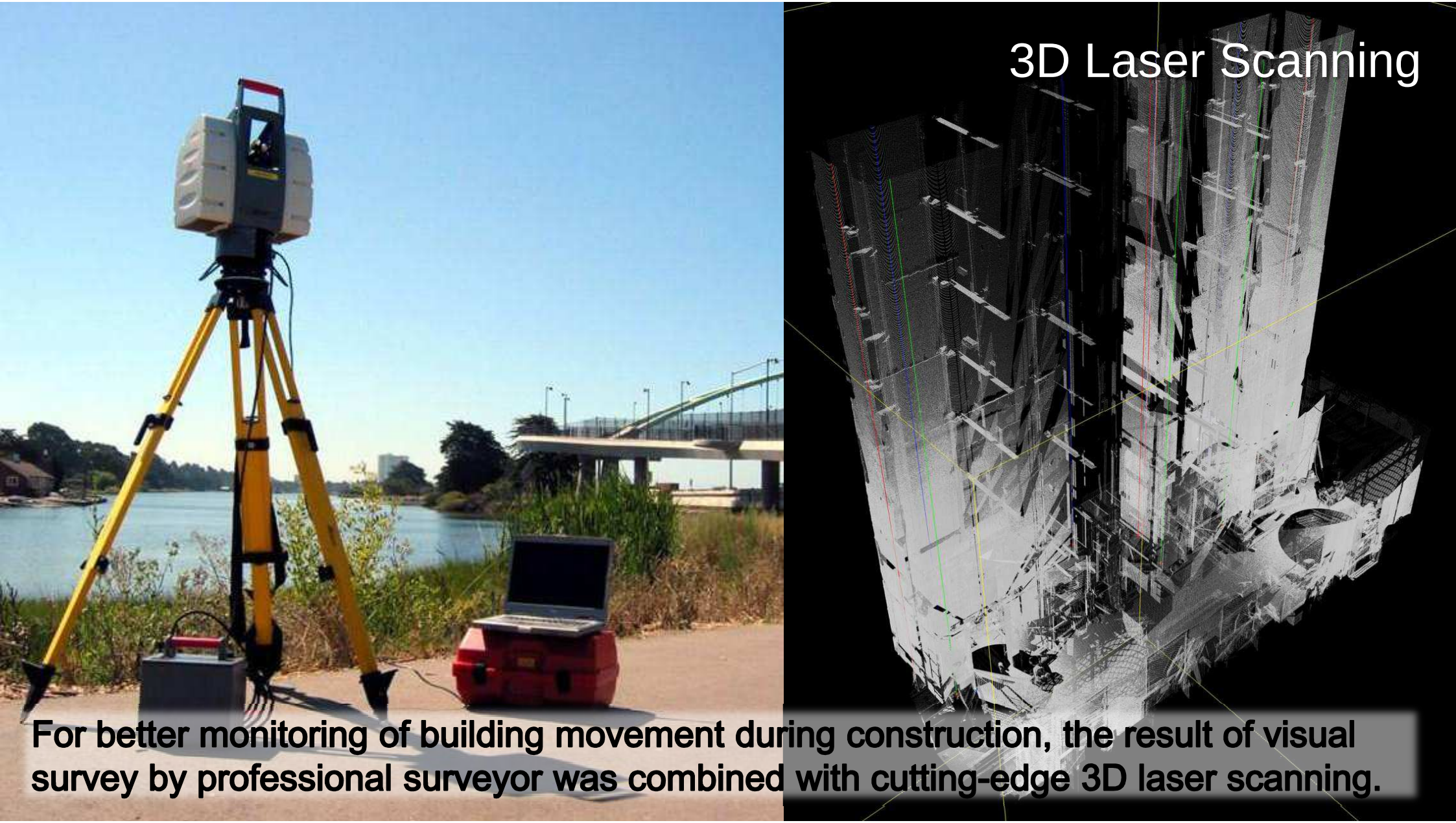
The staged analysis of the transfer girder revealed the differences in member forces and displacement. Based on the result, the supports were removed after 1 month.

Creep & Shrinkage Test

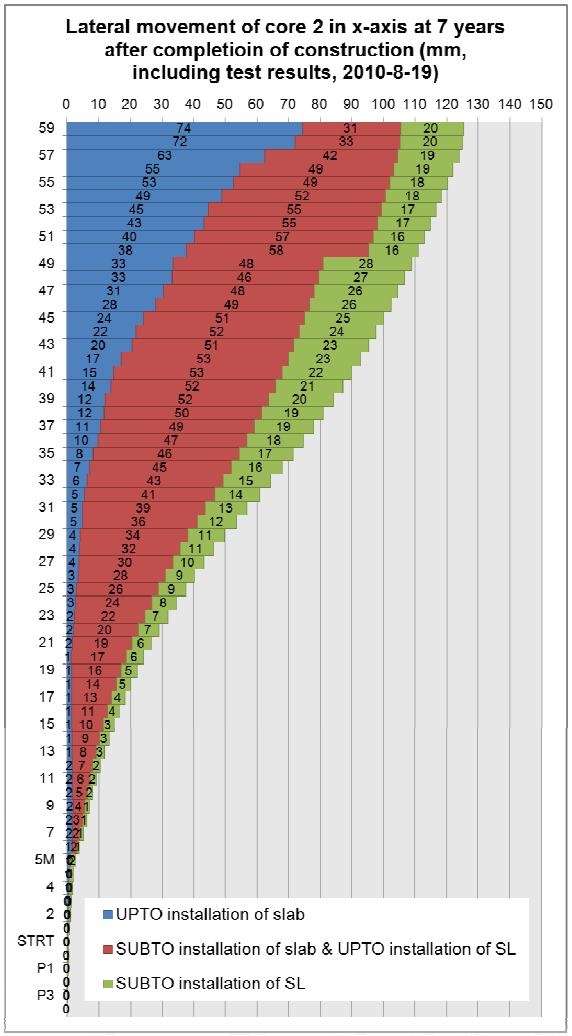


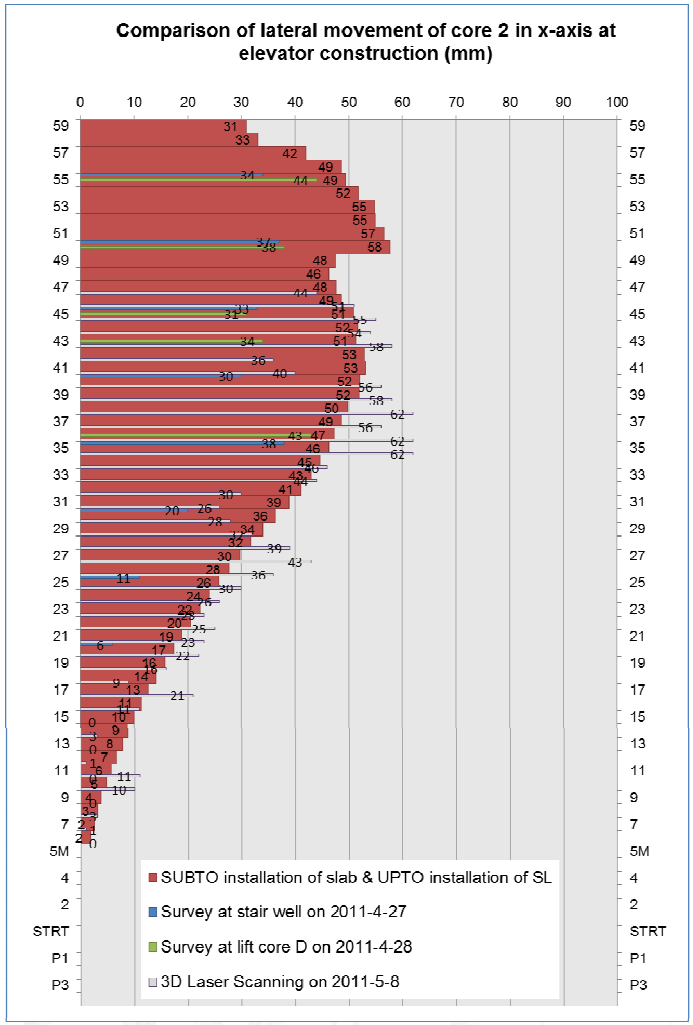


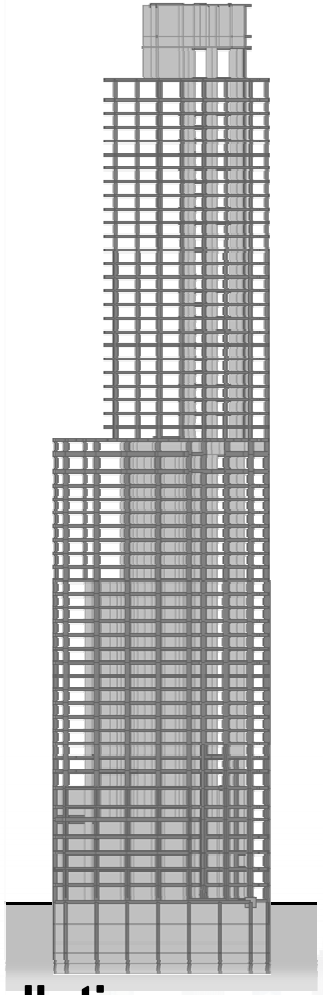
The building movement is refined after its initial prediction based on time-dependent laboratory material testing such as creep, shrinkage and modulus of elasticity.



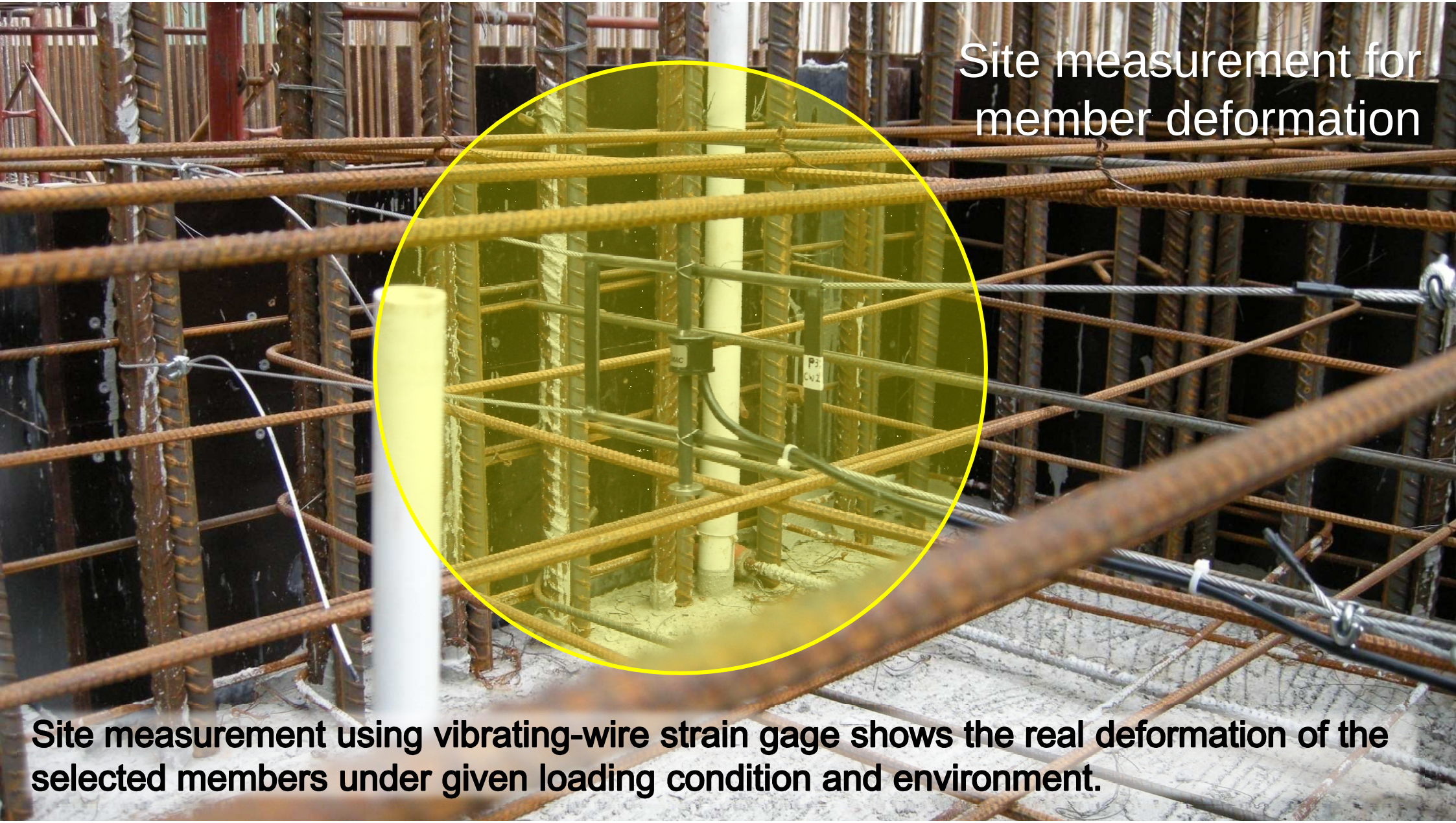
For better monitoring of building movement during construction, the result of visual survey by professional surveyor was combined with cutting-edge 3D laser scanning.





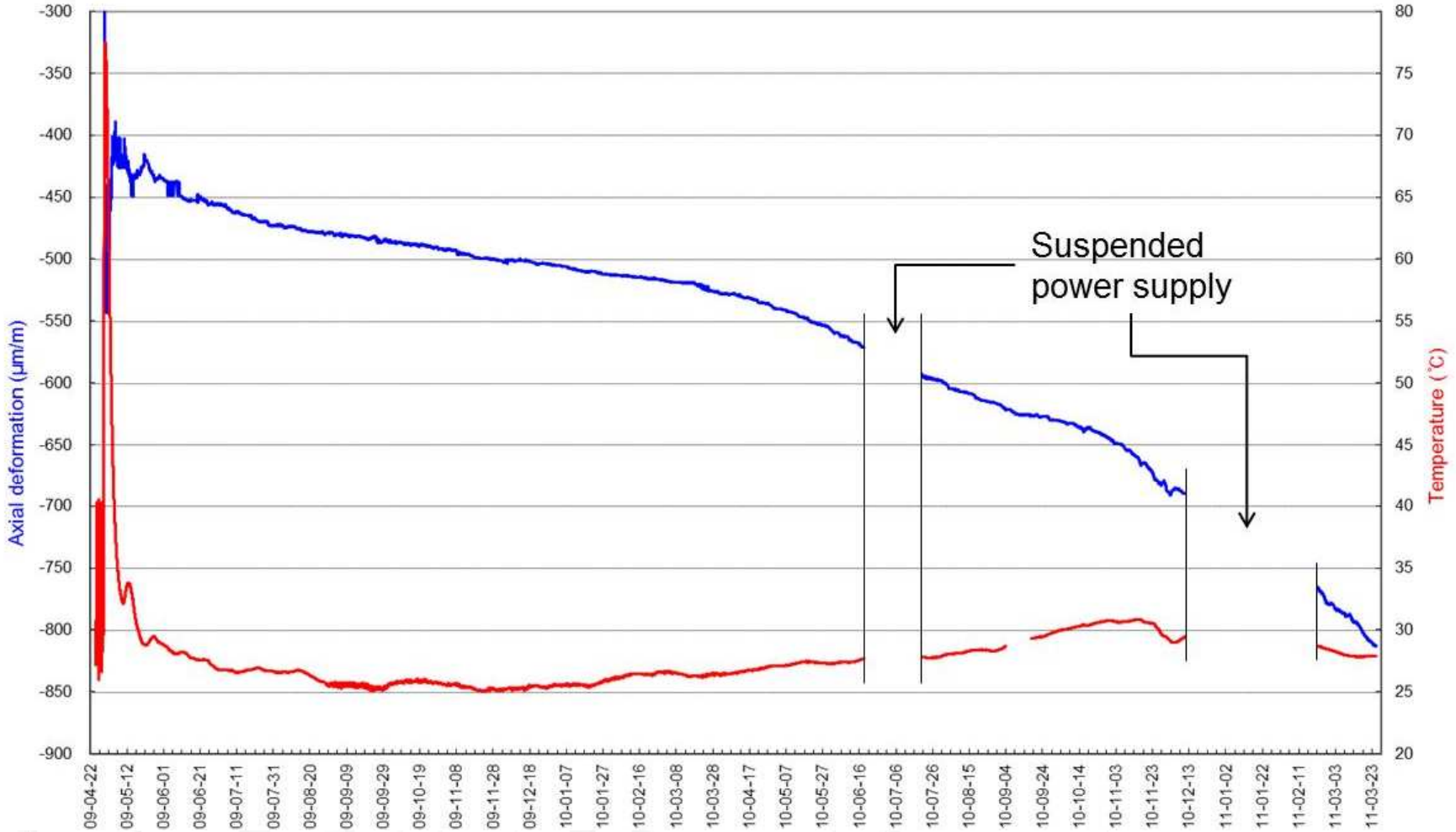


The result of prediction of lateral movement of lift core at time of lift installation was verified by both of visual inspection and 3D laser scanning.



Site measurement using vibrating-wire strain gage shows the real deformation of the selected members under given loading condition and environment.

Example of measured shortening



Column shortening was continuously measured with the variation of temperature in this 2-year graph with some exceptions due to suspended power supply.

Thank You for Attention!!!

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